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EXPERT INSIGHT FOR RAN and In-Building Wireless Subscribers

Can the “cost per GB” trend predict 5G adoption?

Comparative Study of Mobile Markets in the US vs. UK vs. Japan

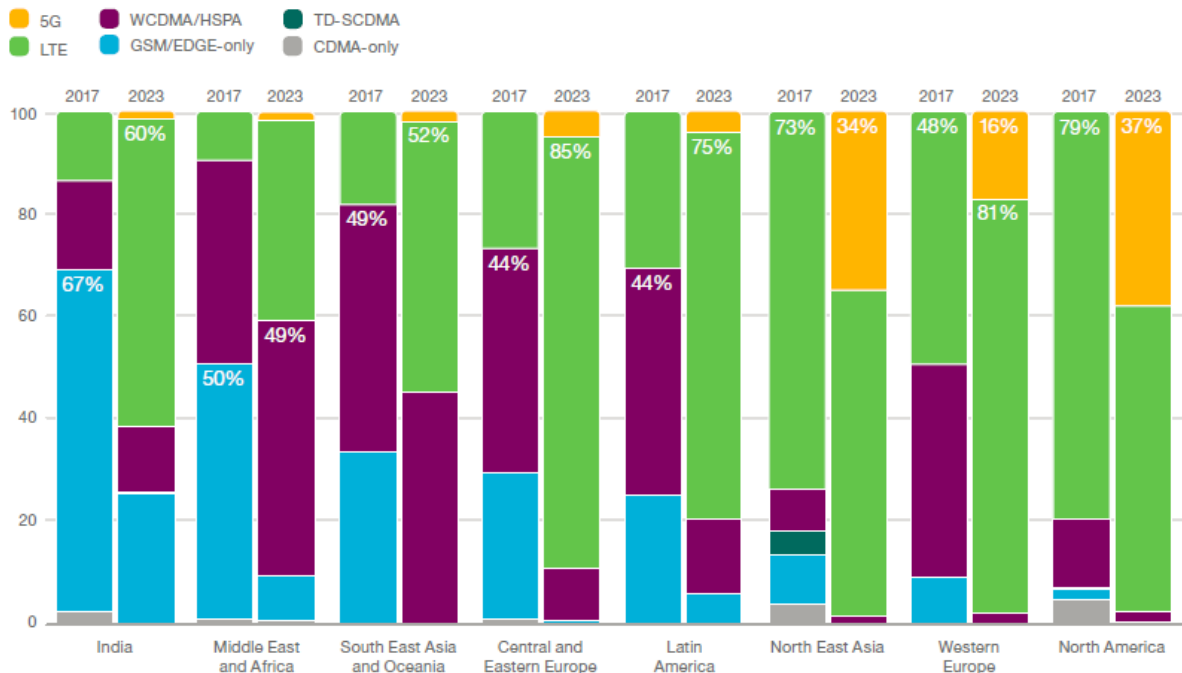
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Introduction

Mobile Experts has been forecasting varying 5G adoption by region. We believe the major operators in the USA, China, Japan, and Korea to lead the 5G shift while the European operators to lag behind. A recent Ericsson Mobility (November 2017) Report also highlights this generally accepted view. According to the report, the North American region is expected to lead 5G uptake with 37% of all mobile subscriptions by 2023 (see Figure 1). The report also forecasts the 5G penetration in the North East Asia region including China, Japan, and Korea to reach 34% by 2023. Meanwhile, the 5G adoption in Western Europe is expected to move more slowly with the 5G penetration reaching less than half of North America or North East Asia. (Note that the Mobile Experts forecast is similar but more strongly weighted toward Asia).

Mobile subscriptions by region and technology (percent)



Source: Ericsson Mobility Report, Nov. 2017

Figure 1. Mobile subscriptions by region and technology

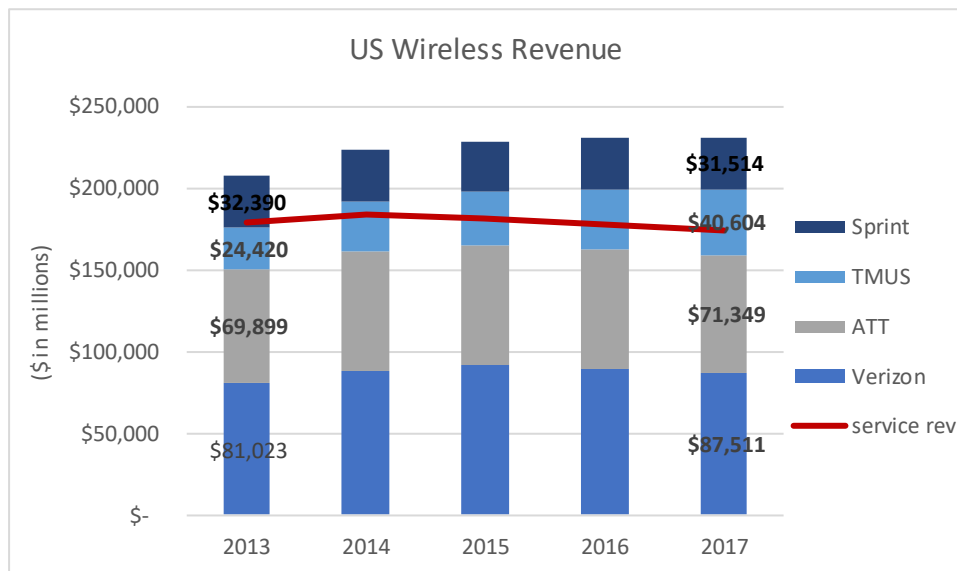
While public announcements from major operators in the USA, China, Japan, and Korea certainly bolster this regional view of the 5G forecast, we have been wondering if some quantitative measures can help predict 5G adoption.¹ In the past year, we have often relied on the “cost per GB” measure to understand unit economics of delivering mobile data traffic using various radio technologies (e.g., LTE, LAA, CBRS over macro or small cells). In this report, we explore major mobile operators in selected markets in the three respective regions to see if financial and operational trends offer insights on why a particular country or market would be more eager to

¹ As analysts, we are always in search of quantitative measures to bolster or refute our predictions and help identify trends to support our analyses.

adopt 5G while others may be less inclined to do so. In this report, we explore the mobile market trends in the USA, Japan, and the UK as a case study of representative markets in the North American, North East Asia, and Europe.² In this report, we study market trends including mobile pricing and cost trends based on financial results of the major operators in those countries.

USA Mobile Market Trends

With mobile penetration reaching over 100%, the US market is reaching a saturation point in terms of basic mobile telecom services. While the overall wireless revenue including equipment sales of the four major operators has increased, the combined service revenue has actually declined (see Figure 2). With the increasing adoption of equipment installation and “bring your own device” service plans, equipment sales make up an increasing portion of operators’ overall wireless businesses.



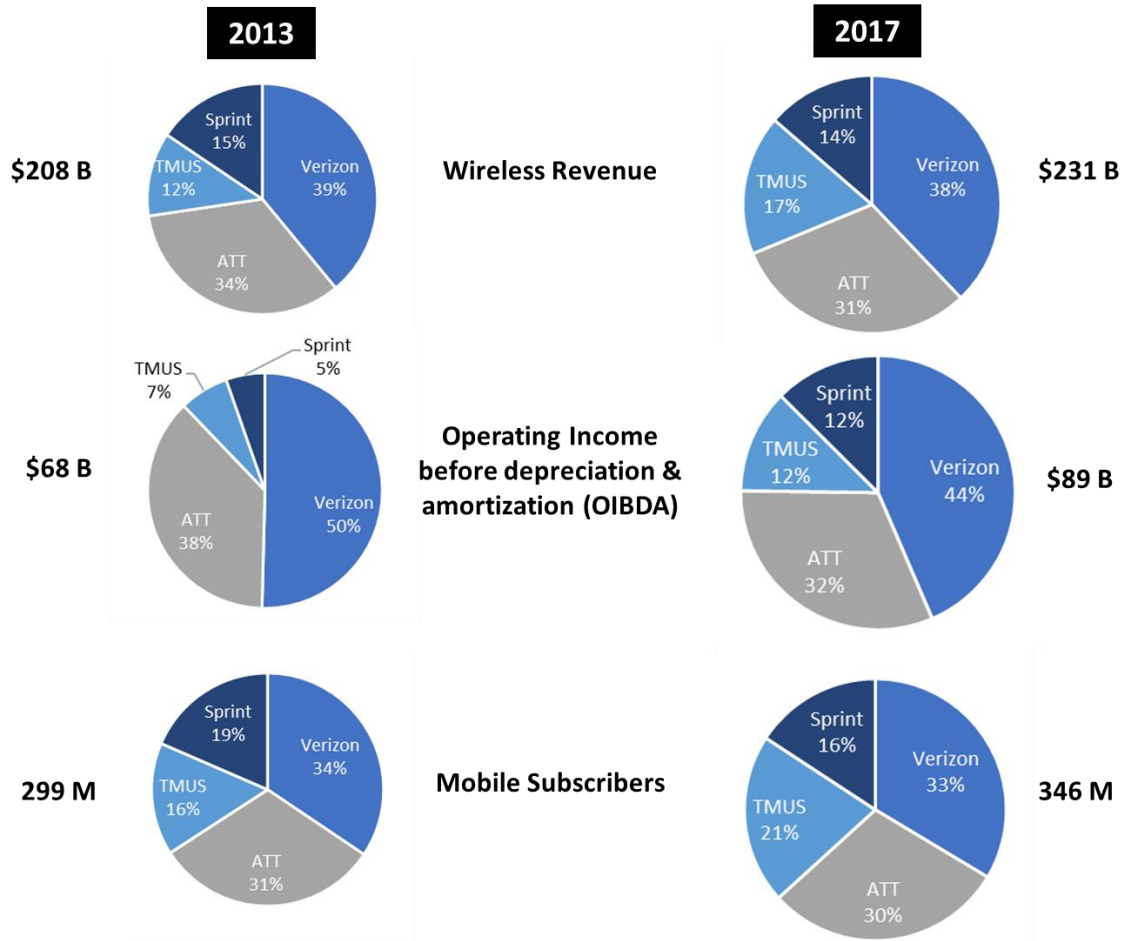
Source: Company reports, Mobile Experts

Figure 2. US wireless service revenue of four major operators

Based on financial and operational metrics such as revenue and profitability as well as mobile subscriber share of the four major operators, the US mobile market has become more competitive over the years. For instance, at the end of 2013, Verizon and AT&T together captured about 75% of wireless revenue and close to 90% of the industry’s profit (in terms of operating income before depreciation and amortization, OIBDA). The top two operators served 65% of the total subscribers with arguably the majority of “high value” subscribers belonging to high-

² While China is certainly expected to be one of the leading markets of 5G, we have decided to look at Japan instead as we wanted to focus on market forces and trends which are less pronounced in China where government directives heavily influence market investment decisions.

income brackets. By the end of 2017, the combined share of Verizon and AT&T has decreased to less than 70% of wireless revenue, 76% of industry profit, and 63% of mobile connections. T-Mobile US, in particular, has done well to capture share away from its competition. It has now taken a solid number three position in the US mobile market.



Source: Company reports, Mobile Experts

Figure 3. Growing US wireless market has become more competitive over the years

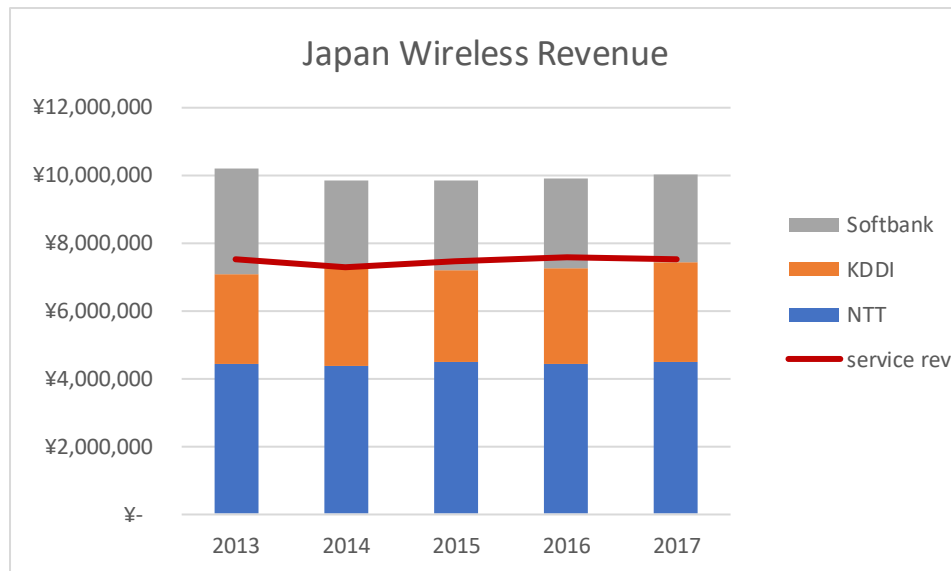
Despite these gains, Verizon and AT&T still hold the bulk of the industry's profit. They hold economies of scale advantages over T-Mobile and Sprint with a large pool of "high-value" mobile subscribers and network advantages in terms of coverage and spectrum depth (especially for AT&T which has access to additional 700MHz spectrum as a part of its FirstNet win).

It is noteworthy that US mobile investment continues, despite flat revenues. The two "challenger" operators appear ready to invest more in networks to remain competitive players in the marketplace. Despite a low single-digit growth in the overall wireless business over the past

five years, the four major players look ready to compete more aggressively through network investments, including 5G, in the coming years.

Japan Mobile Market Trends

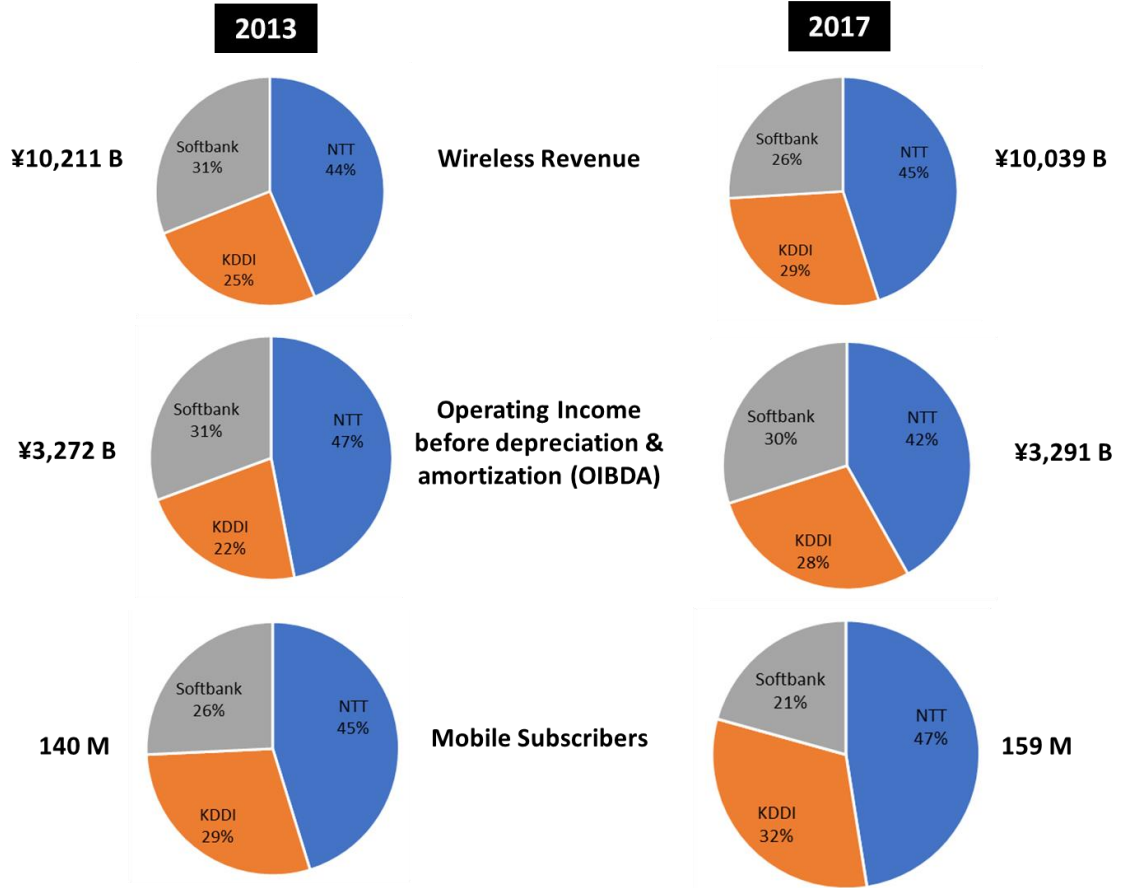
The Japanese mobile market is a more concentrated “three-player” market with NTT docomo, KDDI, and Softbank. Without significant “challenger” operators (like T-Mobile US and Sprint in the US) looking to take share away from top players, the market has remained relatively flat over the past five years with the operators largely maintaining their market share. In this more stable market environment, the overall industry service revenue has remained constant. This is a notable contrast to the US market where the challenger moves with aggressive pricing has resulted in a lower service revenue.



Source: Company reports, Mobile Experts

Figure 4. Japan wireless service revenue of three major operators

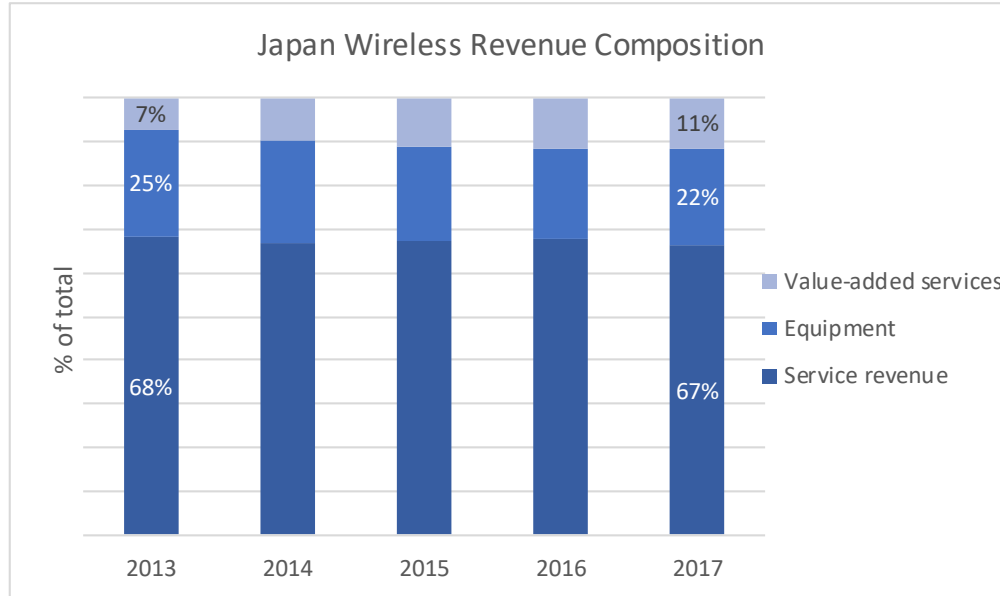
In taking a closer look at financial and operational trends, the overall Japanese mobile market remains relatively flat in terms of aggregate industry revenue and profitability. However, it is worth noting that the market continues to grow its mobile connections through demand stimulation by the operators such as introduction of family share plans, variety of data-SIM plans, bundled discounts, and promotion of secondary devices like tablets, mobile routers, etc. The number of LTE subscribers has risen quickly in Japan as operators enhance their LTE systems with advanced features like 256 QAM, MIMO, and carrier aggregation. For example, NTT DoCoMo now has over 60% of its connections on LTE.



Source: Company reports, Mobile Experts

Figure 5. Flattish Japanese wireless market remains stable over the years

In addition to LTE network enhancements, Japanese operators have been active in promoting value-added mobile services like mobile video, mobile pay, etc. to stimulate demand and expand market opportunity beyond basic telecom connectivity services. Over the past five years, the Japanese operators in aggregate has increased its share of revenue derived from these value-added services from 7% to 11%. NTT DoCoMo's *d Payment* (mobile pay) and *dTV channel* (video service) are some notable examples.

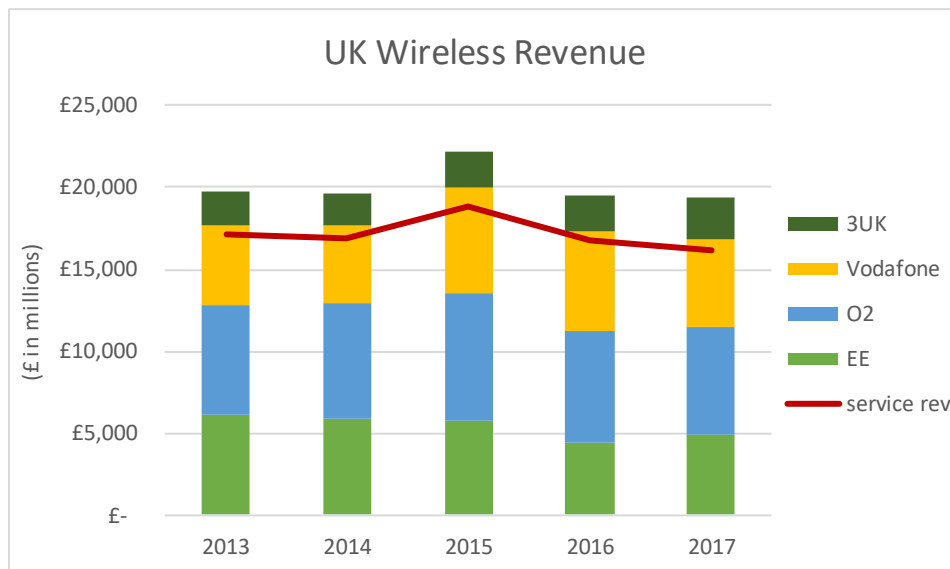


Source: Company reports, Mobile Experts

Figure 6. Value-added services make up an increasing share of mobile revenue in Japan

UK Mobile Market Trends

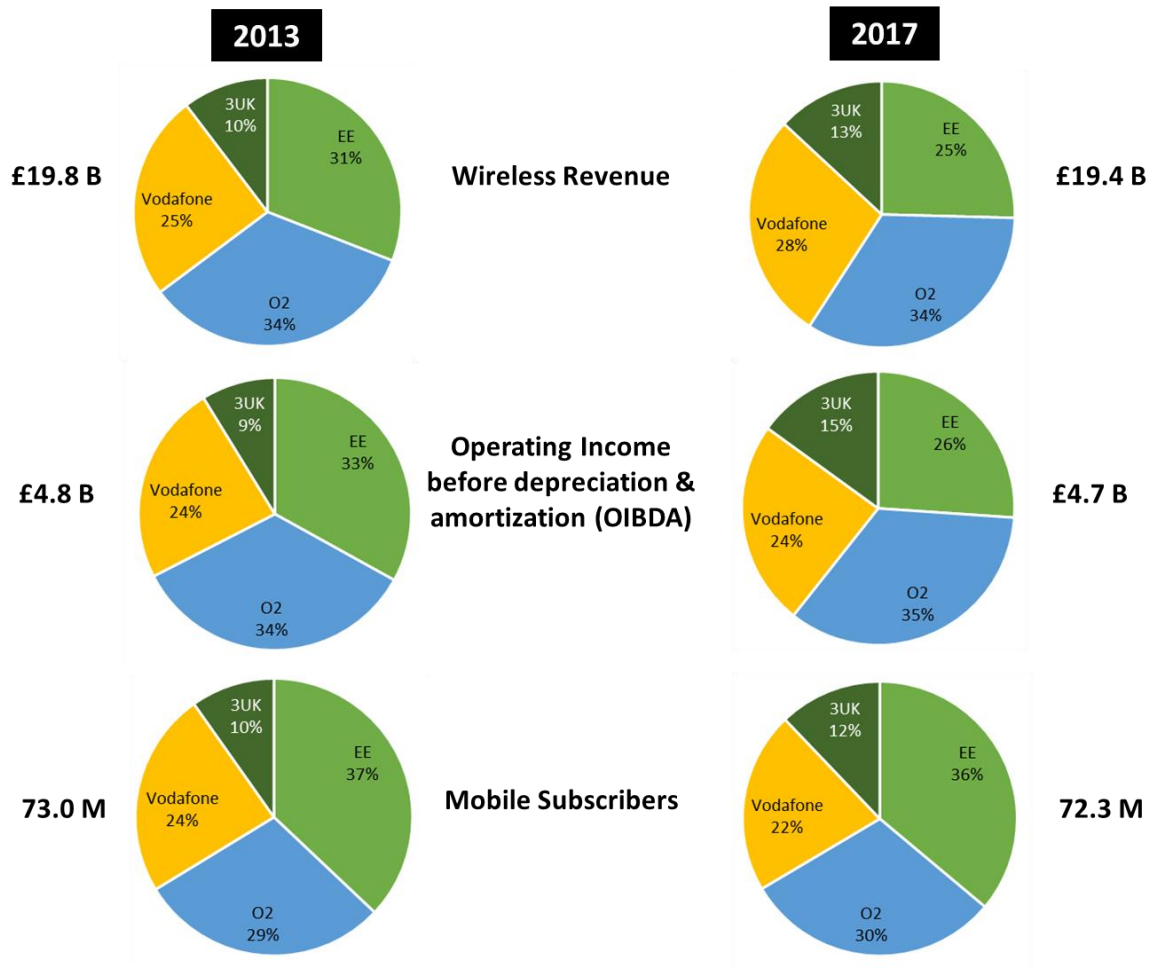
The UK mobile market is a “four-player” market similar to the US with EE, O2, Vodafone, and Three competing in the market. The revenue picture is similar to the USA or Japan with a slight decline from £17.1B in 2013 to £16.2B in 2017. More significantly, the UK has experienced declining profitability over the same period.



Source: Company reports, Mobile Experts

Figure 7. UK wireless service revenue of four major operators

While there are many explanations to the stagnant market condition in the UK, “hands-on” regulatory environment in the UK, and Europe in general, has certainly played a part. The operators seem reticent to make major network investments while there are uncertainties around pricing and market regulations.³ It should be noted that with the overall mobile revenue opportunity in the UK representing just over 11% of the US market, and the market profitability hovering around 7% of the US market, the “upside” market opportunity for the UK operators are certainly much less compared to the US. It’s hard for operators in a small market to make money.



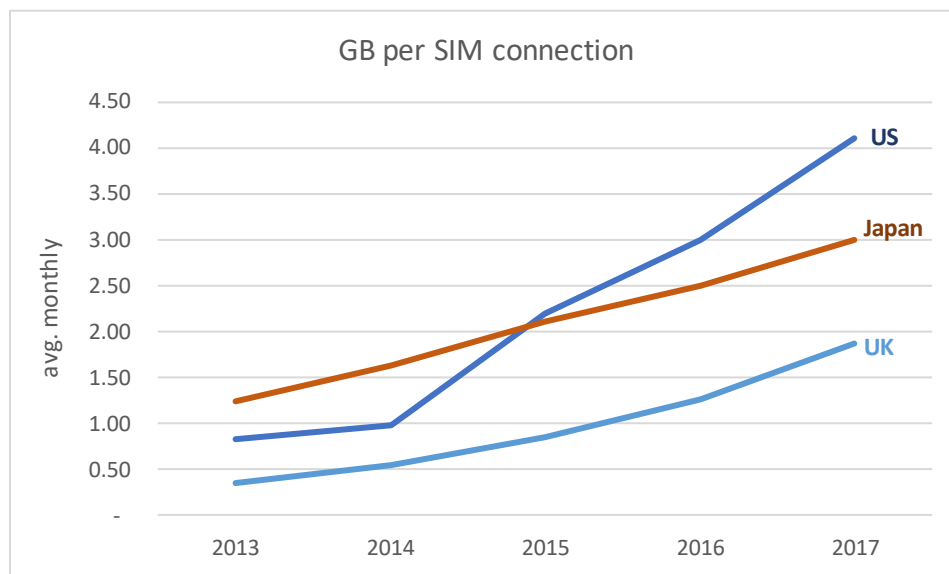
Source: Company reports, Mobile Experts

Figure 8. UK wireless market has remained flat over the years

³ UK’s regulatory body, Ofcom, and EU regulatory body has thwarted the industry’s market consolidation attempts, most recently when Three attempted to merge with O2 to combine their operations.

Data Usage Growth

Despite the differing market environments across the US, Japan, and UK, one universal market trend that they all share is that the data usage on mobile networks is increasing rapidly. Increasing smartphone penetration and LTE network deployments are fueling user adoption and mobile data growth. According to tefficient⁴, which tracks mobile data pricing and usage patterns around the globe, the average monthly data usage per SIM connection has been growing at varying degrees depending on market pricing, smartphone and LTE penetrations. The average data usage per connection in the US far outpaces Japan and the UK. With widely available “unlimited” plans which we have long talked about⁵, the stimulation of data demand in the US has far outpaced the other two markets as shown below. The average data usage per connection has been steadily growing in Japan with a slight uptick in the past year as operators look to stimulate demand with favorable data pricing and other bundled services. Meanwhile, the data usage per connection in the UK is well below that of the US and Japan. According to OpenSignal, LTE penetration in the UK lags behind (at 66%) compared to the US (at 81%) and Japan (at 90%).⁶



Source: tefficient, CTIA, Ericsson, Mobile Experts

Notes:

1. US GB per SIM figures are from Tefficient public industry analyses on mobile data pricing and usage.
2. US GB per SIM figure for 2013 is calculated based on CTIA reporting 3.23 trillion MB data traffic.
3. US GB per SIM figure for 2017 is derived from the Ericsson Mobility report estimating 7.1GB/month smartphone usage in 2017 relative to 5.2GB/month in 2016. Average is lower since not all connections are smartphones
4. Japan GB per SIM figures are from Tefficient, except for the 2013 figure which is an estimate based on the observed linear trend
5. UK GB per SIM figures are from Tefficient.

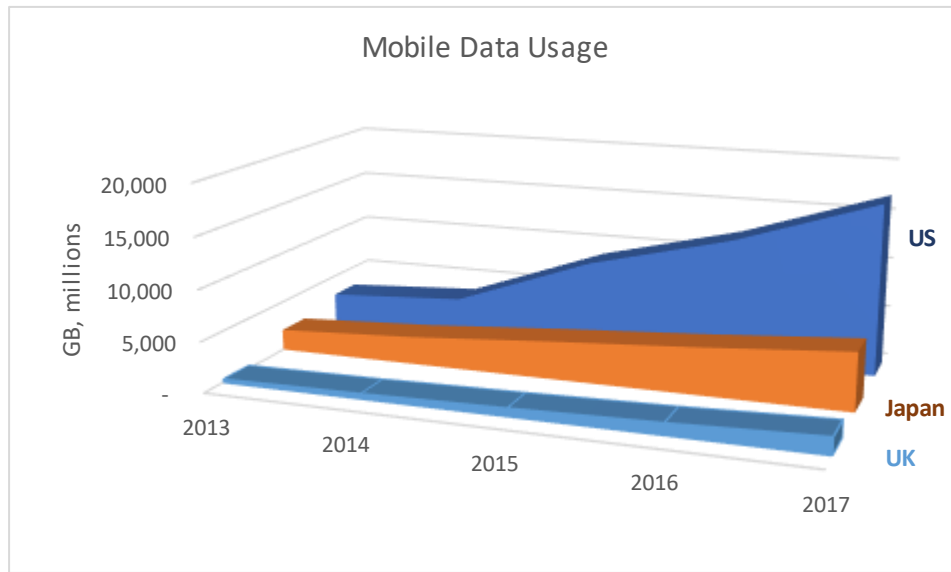
⁴ Tefficient is a market intelligence firm based in Europe and provides public industry analysis on mobile data pricing and usage. Their public analyses are at: <https://tefficient.com/analysis/public-industry-analysis/>

⁵ <https://www.fiercewireless.com/wireless/mun-it-looks-like-unlimited-data-here-to-stay>

⁶ OpenSignal's "the State of LTE" report, June 2017.

Figure 9. Average monthly GB per SIM connection for US vs. UK vs. Japan

Multiplying the average monthly data usage per SIM connection by the total number of subscribers or connections provides a glimpse of how much data traffic is served by the aggregate mobile networks in each of the countries as shown below. With close to 350M mobile connections, the scale of mobile data usage in the US is significantly greater than Japan (with close to 160M mobile connections) and the UK (with over 70M connections).



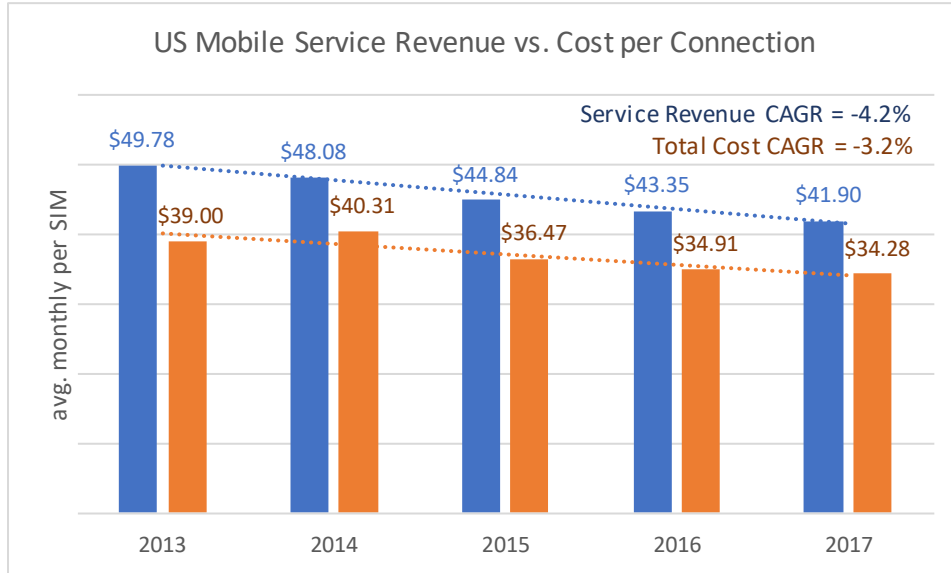
Source: Mobile Experts

Figure 10. Mobile data usage in the US vs. Japan vs. UK

As shown above, the mobile data usage in the US is growing at close to 55% CAGR, from 3 billion GB in 2013 to over 17 billion GB in 2017. In comparison, the mobile data usage in Japan is growing at a more moderate pace (29% CAGR), with 5.7 billion GB served in 2017. Although the mobile data usage in the UK is growing at over 50% CAGR, its mobile data usage in 2017 only reached 1.6 billion GB in 2017. At the end of 2017, the annual mobile data usage in the US was over 10x higher than the UK and 3x higher than Japan. This sheer volume of mobile data traffic and the fast growth rate could explain the US mobile operators' motivation to make the shift to LTE-Advanced and 5G technology features to help meet the growing tide of rising mobile data traffic.

Revenue vs. Cost per Subscriber/Connection

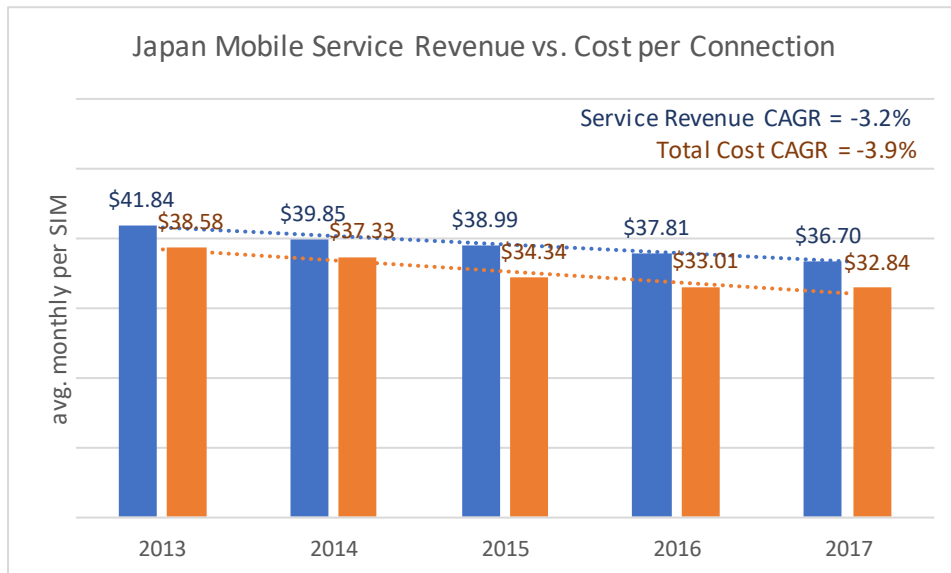
To gauge the unit economics of service revenue vs. cost, it is helpful to highlight average monthly service revenue and the total cost of serving each mobile connection or subscriber. A series of figures below highlight revenue vs. cost of serving each mobile connection in the three markets.



Source: Mobile Experts

Figure 11. US mobile service revenue vs. total cost per connection

Although average revenue per unit (ARPU) has come down with gradually declining service revenue, the US market still enjoys high ARPU that is the envy of many other operators around the world. While the operators have decreased their unit cost of serving each connection (at -3.2% CAGR decline), that has not kept up with the declining service revenue per connection (-4.2% CAGR decline).

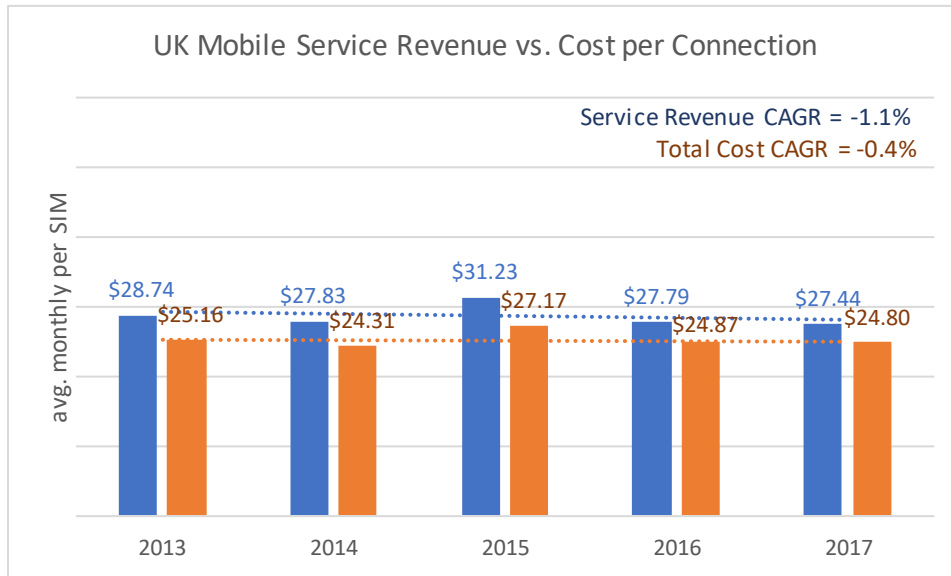


Source: Mobile Experts

Figure 12. Japan mobile service revenue vs. total cost per connection

In a more stable competitive environment, the operators in Japan have been successfully cutting the total cost per connection faster than the declining service revenue per connection. This

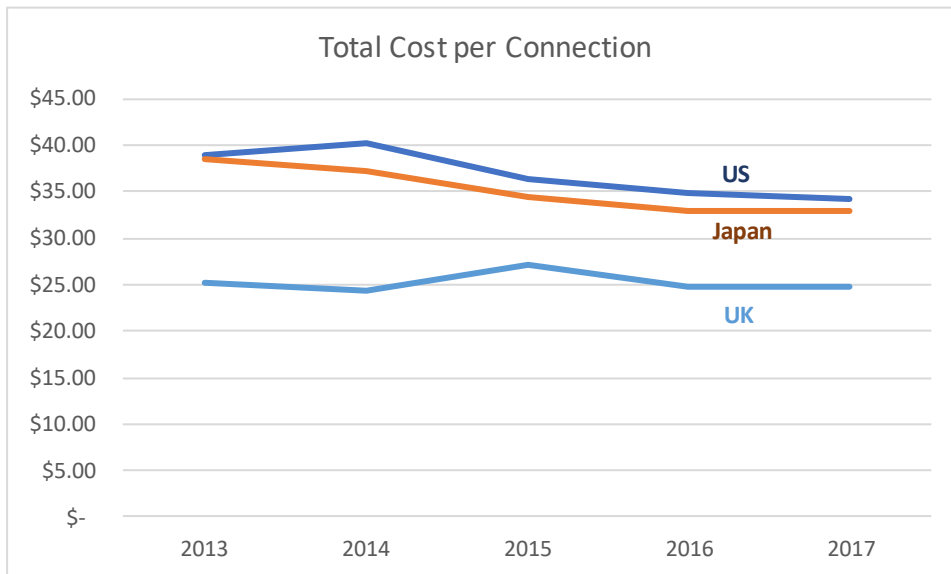
“surplus” essentially allows the operators in aggregate to make more profit with each additional connection or subscriber added to the network.



Source: Mobile Experts

Figure 13. UK mobile service revenue vs. total cost per connection

The UK market is a lower APRU market compared to the US or Japan. While the operators have been able to maintain cost reduction in line with slightly declining service revenue, the average profit margin in terms of OIBDA margin is less than 25%, which is much lower than 38% average in the US and 33% in Japan.



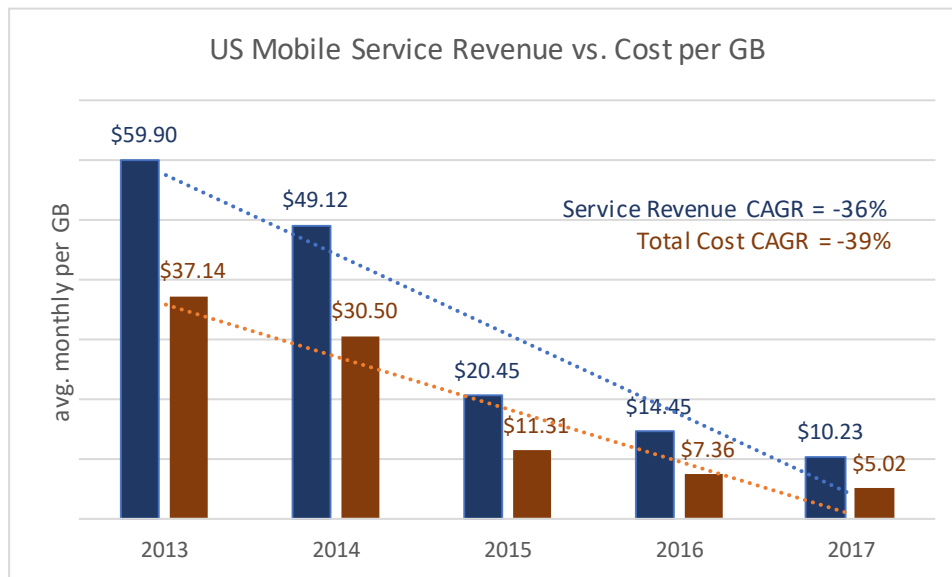
Source: Mobile Experts

Figure 14. Total cost per connection trend in the US vs. Japan vs. UK

With almost 350M mobile connections, it will be difficult to dramatically reduce the total cost per connection in the US especially in a competitive market where it will be difficult to cut the customer acquisition and retention costs. Similarly, the Japanese market with about 160M mobile connections appear to share a similar trend as the US. The UK cost is much lower than the other two largely with a smaller mobile connection base that is almost one-fifth that of the US.

Revenue vs. Cost per GB

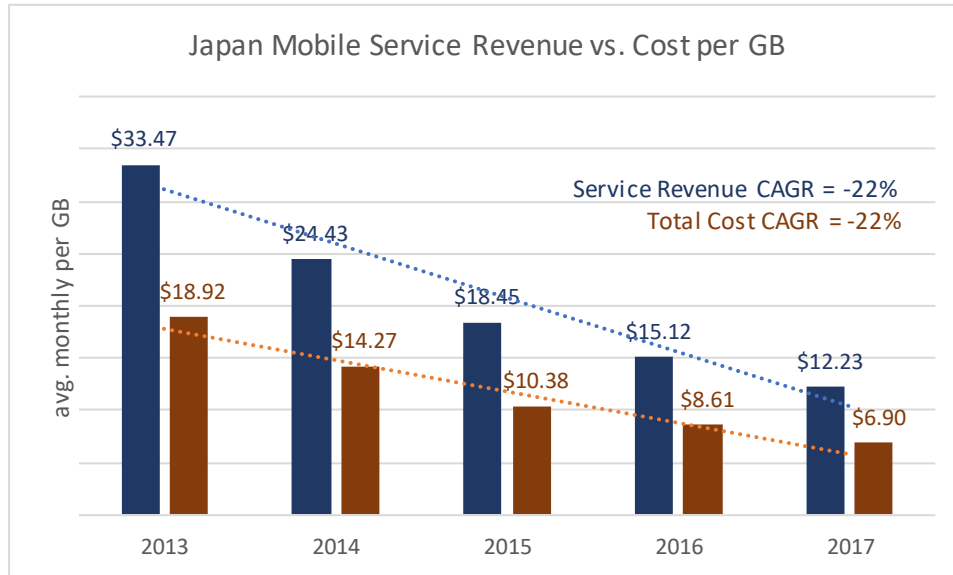
Another way to gauge the unit cost is to reflect the total cost, including cost of services, selling and general administrative costs, and cost of handsets, in terms of data usage. It should be carefully noted that this “cost per GB” is inclusive of all other costs beyond simple network costs. (In previous Mobile Experts reports on “cost per GB,” we only reflected direct network expenses like spectrum, siting, equipment, and direct OPEX costs, but did not account for corporate overheads, marketing expenses, and other selling and administrative expenses. In this analysis, the “cost per GB” reflects the total cost, inclusive of all expenses.) Based on total mobile data usage as previously discussed, the following charts show “revenue vs. cost per GB” for the three markets in our study.



Source: Mobile Experts

Figure 15. US mobile service revenue vs. total cost per GB

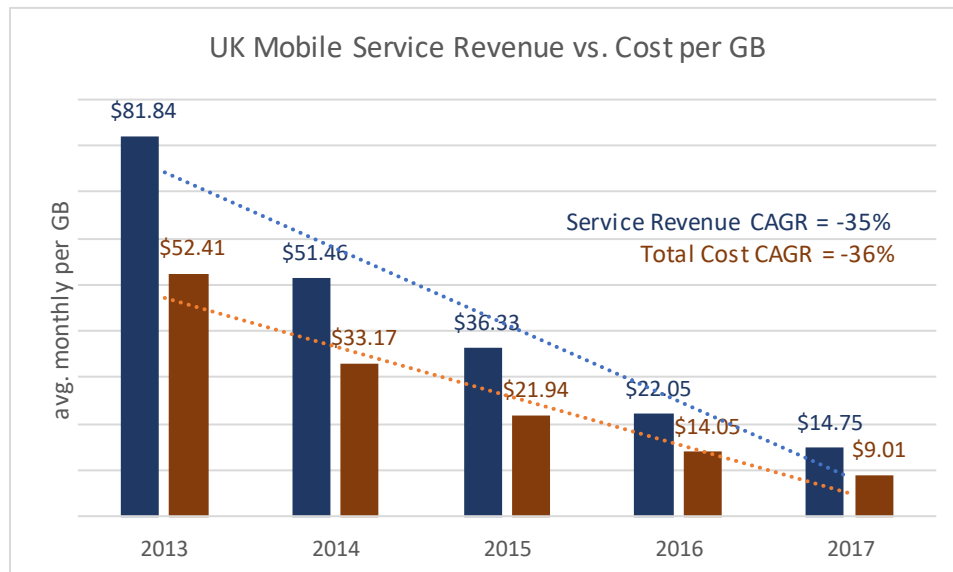
As shown in Figure 10, the data usage in the US far outpaces the other two markets. As such, the total cost per GB inversely reflects the growing data usage. The total cost per GB based on actual usage has dramatically declined from ~\$37 at the end of 2013 to just over \$5 at the end of 2017. The dramatic decline in the total cost per GB is reflective of the dramatic overall rise in data utilization. In other words, the USA is making better use of slack capacity.



Source: Mobile Experts

Figure 16. Japan mobile service revenue vs. total cost per GB

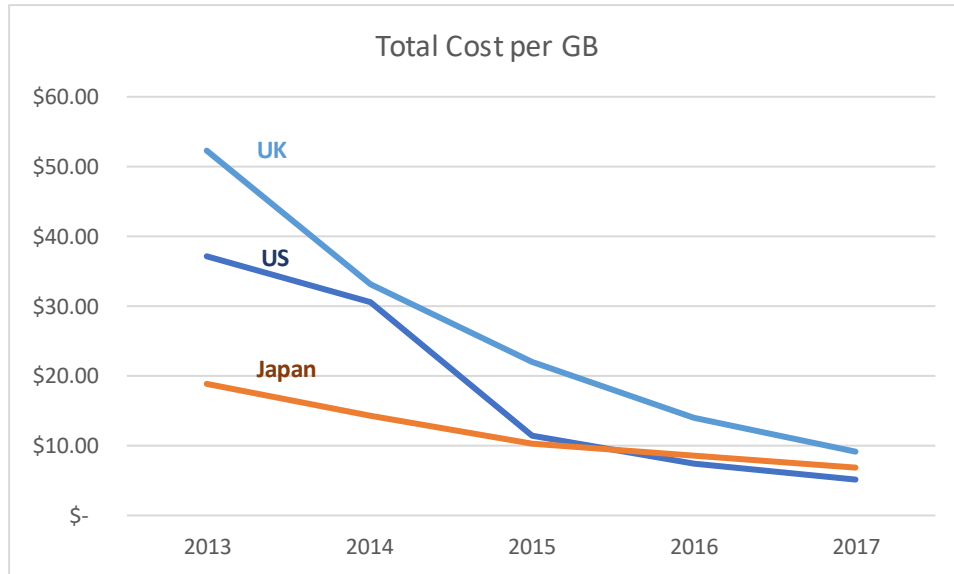
With mobile usage about one-third that of the US, the total cost per GB in Japan is higher than the US, and the declining cost per GB trendline is not as dramatic. Japanese operators are beginning to offer larger data bucket plans and family share plans to stimulate data usage. We expect the total cost per GB to decline faster in the coming years, as consumers utilize LTE and 5G for more video services.



Source: Mobile Experts

Figure 17. UK mobile service revenue vs. total cost per GB

While the mobile data usage growth rate in the UK is higher than Japan, the mobile data usage in absolute terms is much smaller in comparison to the US or Japan. Hence, the total cost per GB remains far higher than the other two larger markets.



Source: Mobile Experts

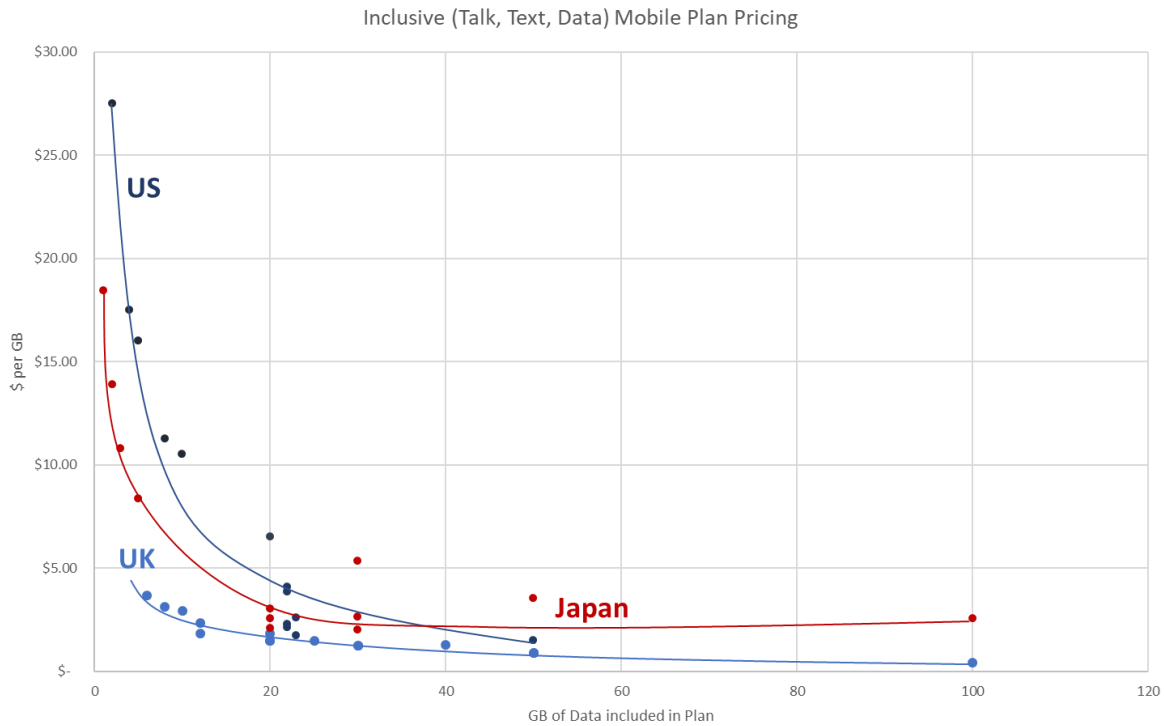
Figure 18. Total cost per GB trend in the US vs. Japan vs. UK

A comparative look at the total cost per GB trendlines of the US vs. Japan vs. UK shows that the US now has the lowest cost per GB of the three markets. With more competitive market dynamics and heavy mobile data usage, the US operators need to further drive the cost per GB even lower to maintain high profitability that they enjoy. This may be one of the key motivators for the US operators to make 5G investments early on to take advantage of lower cost per GB economics of 5G mobile broadband.

Pricing Trend

While there is a general correlation between lower pricing and higher data usage, this cannot be applied across markets. In other words, while the pricing per GB may be lower in the UK vs. Japan or the US, it does not translate into higher data usage in the UK. The pricing trend can only be applied within a market relative to how other national operators within the market respond. For example, the below chart depicts recent snapshots of mobile data plans across the three markets. Translating local currency into US dollar, we arrive at various national mobile data pricing (inclusive of talk, text and data charges) per GB. As shown, the mobile data pricing per GB is more expensive in the US vs. Japan, and furthermore, the mobile pricing in Japan is more expensive than the UK. While the constant currency mobile data pricing in the US is more expensive than the other two markets, the data usage in the US is growing at a faster pace than the

other two “cheaper” markets. In short, we can’t simply explain higher data usage based on pricing alone.



Source: Mobile Experts, company websites

Notes:

1. US mobile data plan pricings are based on snapshot of family plans, single-line data plans taken from company websites extracted in January and February 2018.
2. Japan mobile data plan pricings are based on NTT family share and data pack plans and KDDI's au flat and au Pitatto plans
3. UK mobile data pricings are based on SIM-only pricings from company websites taken February 2018.
4. The following foreign exchange rates were applied for constant currency figures: \$1 = 107 yen and \$1 = 0.68 GBP.
5. The pricing per GB includes line charges and inclusive voice, text, data plans in unlimited plans.

Figure 19. Inclusive mobile data pricing per GB for US vs. UK vs. Japan

Conclusions

In this report, we identified the key economic factors driving operator behavior in different regions. Looking at the market from a financial point of view, it's clear that some markets drive a more urgent need for 5G investment. The USA, Japan, and other Asian countries have highly competitive markets with high ARPU, so profit can be achieved with rapid cost reduction.

Five years ago, 2G, 3G, and 4G networks were spread across the country fairly evenly, with slightly more capacity in cities and slightly less in rural areas. This resulted in high utilization in the cities and low utilization everywhere else. As LTE capacity has been added to cities, the

average cost per GB has dropped for the network overall. *5G networks offer between 4x and 20x reduction in cost per GB compared with LTE*, so 5G presents an opportunity to extend this trend. Operators can add very low cost capacity in urban centers, dropping the average cost per GB faster than the decline in revenue per GB.

Operators in high-ARPU markets like the US and Japan are motivated to make the 5G shift to lower the cost per GB economics. However, in some lower-ARPU markets like the UK, and Europe in general, “hands-on” regulatory agencies may be dis-incentivizing the operators to make proactive investments in 5G. The UK operators may be more inclined to increase LTE and smartphone penetration further to stimulate mobile data usage before making the next-generation technology shift towards 5G.

In our view, rising mobile data usage and consequently high network utilization, along with competitive market dynamics with “hands off” regulatory regime on mobile data pricing are key ingredients in incentivizing operators to make the shift to 5G. The basic supply-demand dynamics of rising network utilization and lower-cost network economics are fundamental drivers of the technology shift. The US and Japanese markets exhibit these traits while the UK, and Europe in general, appear less so.

In short, 5G investments are intended to bring down the average cost of data delivery. In markets where consumers are willing to pay for more data, 5G networks are on their way.